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Meeting the Needs of Southeastern Coastal Resource Managers through Coastal Ocean Observing Systems

Braxton C. Davis, Emily A. McDonald
Belle W. Baruch Institute for Marine and Coastal Sciences, University of South Carolina

In cooperation with the Coastal States Organization and the Southeast Coastal Ocean Observing Regional Association

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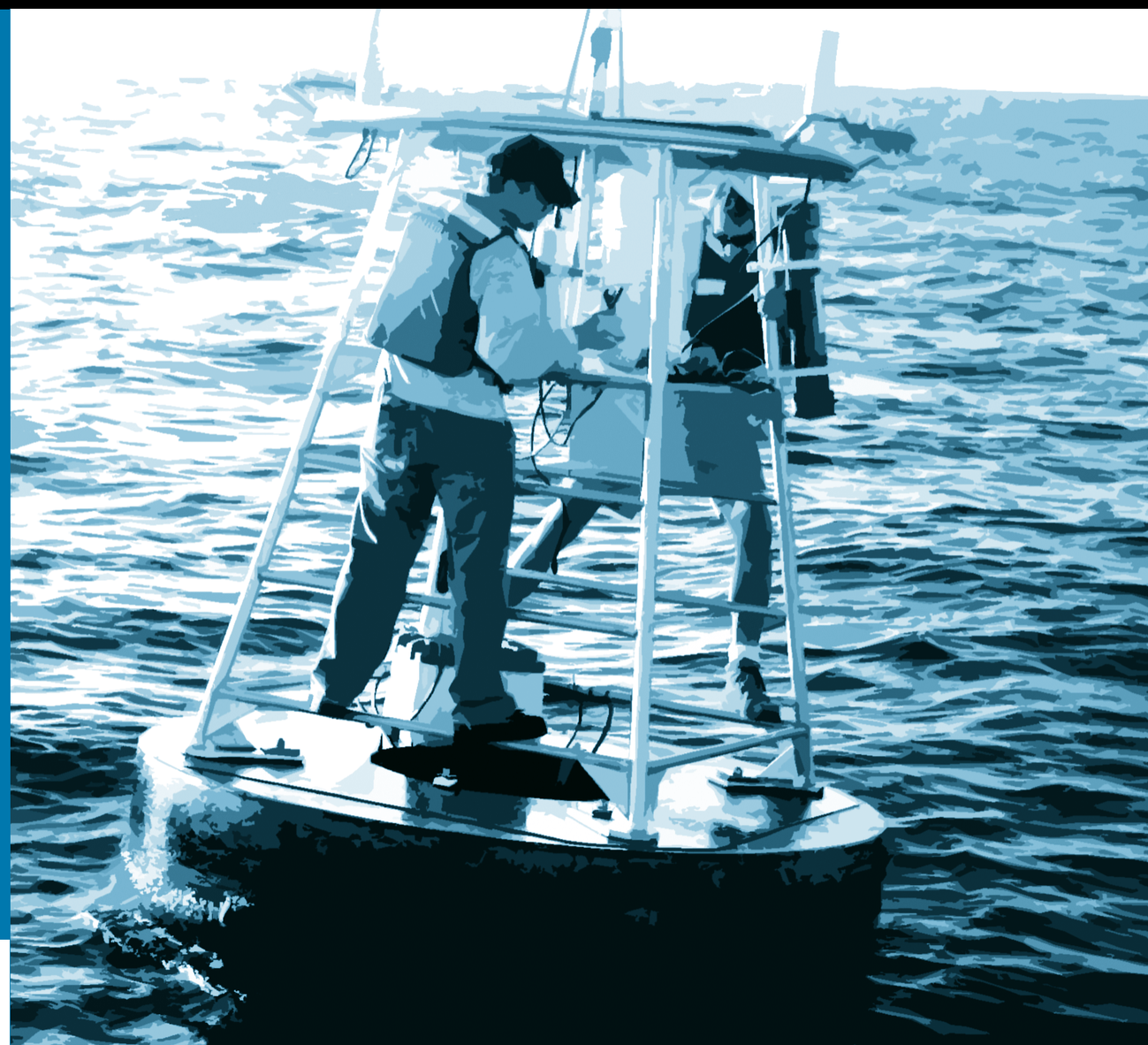

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List of Acronyms

ADCIRC	Advanced Circulation Model
ADCP	Acoustic Doppler Current Profiler
AOM	Atlantic Oceanographic and Meteorological Laboratory, OAR/NOAA
BOD	Biochemical Oxygen Demand
CEMAPS	Coastal & Estuarine Marine Prediction System
CFRE	Cape Fear River Estuary
Caro-COOPS	Carolinas Coastal Ocean Observing and Prediction System
C-MAN	Coastal Marine Automated Network
COMPS	Coastal Ocean Monitoring and Prediction System
COOS	Coastal Ocean Observing System
CORMP	Coastal Ocean Research and Monitoring Project
CREWS	Coral Reef Early Warning System
CSO	Coastal States Organization
CZM	Coastal Zone Management
CZMA	Coastal Zone Management Act of 1972, as amended
EEZ	Exclusive Economic Zone
EFSIS	East Florida Shelf Information System
EISES	Environmental Information Synthesizer for Expert Systems
EPA	Environmental Protection Agency
FCMP	Florida Coastal Management Program
FL COOS	Florida Coastal Ocean Observing System
GOOS	Global Ocean Observing System
HF Radar	High Frequency Radar
IOOS	Integrated Ocean Observing System
MRD	Marine Resources Division
NC-COOS	North Carolina Coastal Ocean Observing System
NDBC	National Data Buoy Center
NERRS	National Estuarine Research Reserve System
NOAA	National Oceanic and Atmospheric Administration
NORLC	National Ocean Research Leadership Council
NOPP	National Oceanographic Partnership Program
NWLON	National Water Level Observation Network
NWS	National Weather Service
OCRM	Office of Ocean and Coastal Resource Management
PORTS	Princeton Ocean Model
QAQC	Physical Oceanographic Real-Time System Quality Assurance/Quality Control
RA	Regional Association
SABSOON	South Atlantic Bight Synoptic Offshore Ocean Observational Network
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SEACOOS	Southeast Atlantic Coastal Ocean Observing System
SECOORA	Southeast Coastal Ocean Observing Regional Association
SFOMC	South Florida Ocean Measurement Center
SURA-SCOOP	Southeastern University Research Association – Coastal Ocean Observing Program

Executive Summary

This report seeks to improve understanding of the potential applications of coastal ocean observing systems in coastal zone management, with a focus on the Southeast region. The study builds on efforts to identify information needs of coastal managers by the Coastal States Organization (CSO) and the Southeast Coastal Ocean Observing Regional Association (SECOORA). The goal of this report is to guide coastal resource managers toward relevant applications of coastal ocean observing systems; and in turn, guide the IOOS community toward improved interactions with the coastal management community.

Section 1 | provides an overview of findings from two recent CSO surveys of coastal managers' information needs. In general, the top three coastal management issues identified were land use change, habitat degradation, and nutrient enrichment. Within these categories, top-ranked technology needs included improved models for prediction and simulation, high-resolution remote sensing, and cost-effective long-term monitoring and sampling capabilities. For this report, specific information needs identified in the two CSO studies were further compiled and categorized as "observation," "modeling/forecasting," and/or "information product" needs.

Section 2 | provides an assessment of current IOOS activities relative to the coastal managers' information needs described in Section 1. Based on a review of eight subregional and one regional COOS programs in North Carolina, South Carolina, Georgia, and Florida, many observing systems in the Southeast are already providing information related to many of the observational, modeling, and product needs described by coastal managers. Although it is beyond the scope of this report to evaluate or validate these data and information products, they hold promise for vastly improving the temporal and spatial resolution of coastal and ocean data, and advancing data integration and synthesis across multiple data collection and modeling efforts.

Section 3 | highlights existing uses of IOOS information by coastal managers through two case studies. The first case study describes a cooperative effort by regional and subregional COOS, universities, and state and local resource managers to respond to a coastal hypoxia event offshore of Myrtle Beach, South Carolina. The second case study takes place on a regional scale, and describes interactions between COOS and the coastal management community in responding to Hurricanes Katrina and Rita in the Gulf of Mexico.

This report presents a "snapshot" of the Southeast region's rapidly developing observing capacities. It does not represent a geographic or thematic "gap analysis" because the needs of coastal managers vary from issue to issue, and because no single observing system can meet the data and information needs of all user groups. Rather, this report identifies existing and planned IOOS activities that can contribute to meeting the information needs of coastal managers, and is intended to provide a foundation for improved dialogue between the coastal zone management community and the coastal ocean observing community in the Southeast region.

Introduction

Coastal Ocean Observing Systems (COOS), developed as part of the U.S. Integrated Ocean Observing System (IOOS), will play an important role in meeting long-standing and future information needs of the coastal management community. While this is one of the stated goals of IOOS, linkages between the observing community and coastal resource management community have only recently begun to be explored in comparison with weather forecasting, fisheries management, emergency management, and recreational and commercial applications. Contemporary "coastal zone management" issues include rapid coastal population growth and land use change, offshore energy activities, aquaculture, water quality and nearshore habitat degradation, coastal storms and other hazards, beachfront management, sea level rise, Harmful Algal Blooms, and other emerging threats to the sustainability of coastal ecosystems and economies. Across this broad range of issues, coastal managers seek to resolve use conflicts and develop coordinated, science-based policies governing coastal activities (see Appendix A for description of state coastal programs in the Southeast).

The U.S. IOOS is in its formative years. Terminologies, methodologies, data management strategies, priorities, and governance frameworks continue to be planned, tested, and implemented from the international to local scales (see NOPP, 2006). Political and financial support for the development of IOOS is originating from the federal, state, and local levels and from a variety of sectors, including maritime industry, national defense, academia, public health, and resource management. The early development phases of IOOS have focused on expanded and improved observations and models of physical oceanographic and meteorological parameters over broad spatial scales. As a result, some perceive these systems to have limited relevance to the nearshore, local-scale concerns of coastal managers. However, as described in this report, offshore observations are already proving essential to understanding coastal ecosystem dynamics at the local scale. In addition, the enhanced data management capacities of coastal ocean observing systems are beginning to be leveraged to integrate data collections from offshore waters to coastal estuaries.

This report presents a "snapshot" of the Southeast region's rapidly developing observing capacities (*Appendix B*). It does not represent a geographic or thematic "gap analysis" because the needs of coastal managers vary from issue to issue, and because no single observing system can meet the data and information needs of all user groups. Rather, this report identifies existing and planned IOOS activities that can contribute to meeting the information needs of coastal managers, and is intended to provide a foundation for improved dialogue between the coastal zone management community and the coastal ocean observing community in the Southeast region.

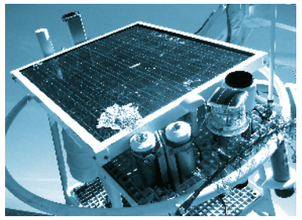
Overview of the U.S. Integrated Ocean Observing System

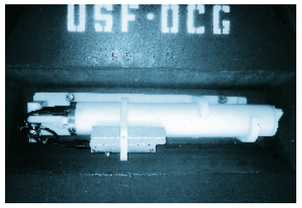
"OceanUS" is an interagency planning office created in May 2000 by the National Oceanographic Partnership Program (NOPP) to establish a sustained, integrated, and operational ocean observing system (IOOS). The general goal of IOOS is to provide public and private stakeholders with useful coastal and global ocean data and products (NOPP, 2004). IOOS also seeks to efficiently link observations to modeling through expanded data management capacities (US Ocean Commission, 2004). Within the IOOS framework, data are collected in real and near real-time via buoy arrays, stationary platforms, ships, drifters, and satellites. Ocean.US has identified seven national needs that IOOS will serve, including:

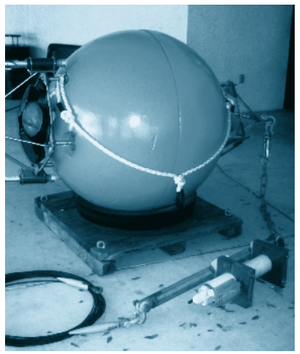
1 | Management of resources for sustainable use;
2 | Detection and forecasting the oceanic components of climate variability;
3 | Preservation and restoration of marine ecosystems;
4 | Mitigation of natural hazards;
5 | Reduction of public health risks;
6 | Improvements in safety and efficiency of marine operations and;
7 | Improvements in national security.

The portions of IOOS that serve coastal ocean areas are commonly referred to as Coastal Ocean Observing Systems (COOS). Supplementing an existing "national backbone" of federal observing platforms (*Appendix C*), COOS are regional and sub-regional systems located within the U.S. Exclusive Economic Zone (EEZ), including estuaries to the head of tides and the Great Lakes (NORLC, 2005). There is no official definition of a COOS, but all share several common characteristics and are built upon similar frameworks [Malone, 2003; U.S. Ocean Commission, 2004; Ocean & Coastal Observation System Act of 2005 (S. 361, H.R.1584 and 1489); Ocean.US, 2005]:

1 | Long-term and sustainable coastal/ocean data collections;
2 | Observing platforms (ships, satellites, buoys, moorings and/or drifters) used for deployment of instruments and sensors which in turn sample, detect, and measure environmental variables;
3 | A telecommunications subsystem that receives and transmits data in a timely manner for defined user groups;
4 | An information management subsystem for collection, storage, dissemination and/or assimilation of data, products, and metadata;
5 | A research and development program;
6 | A modeling and applications subsystem for data synthesis, analysis and creation of useful products; and
7 | An outreach, education, and training program







A wide range of activities may fall into each of these categories, but these activities are not clearly reflected in the diverse titles (and acronyms) adopted by observing systems. For example, "increased observations" may be targeted toward nutrients, biological indicators, or research applications (e.g. storm surge modeling, marine protected areas, etc.); "data management" activities may include regional data inventories, metadata support, data aggregation/standardization, coordination of observations, and/or development of quality assurance/quality control (QA/QC) procedures; and "information products" may include a broad range of data translations, synopses, and decision-support tools for different users, including site-specific climatologies, reports, websites, and GIS applications, among others.

Goals and Objectives of the Report

This report seeks to improve understanding of the applications of coastal ocean observing systems, with a focus on how these applications can meet the needs of the coastal management community in the Southeast region. The study builds on recent efforts to identify information needs of coastal managers by the Coastal States Organization (CSO, 2004a; 2004b). The goals of this study are to: 1) guide coastal resource managers toward relevant applications of coastal ocean observing systems; and 2) guide the IOOS community toward improved interactions with the coastal management community in the Southeast region. Specific objectives include:

1 | Providing an assessment of current IOOS activities relative to the coastal managers' information needs as identified in recent CSO reports; and
2 | Highlighting existing uses of IOOS information by coastal managers.

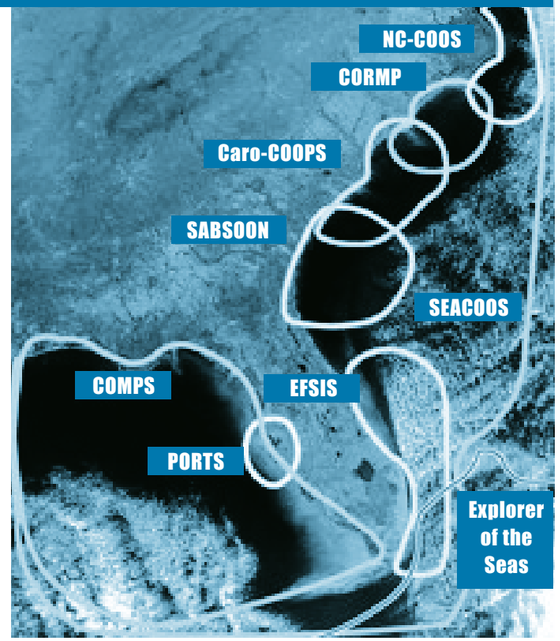
Study Area

This study examined eight subregional and one regional COOS programs in North Carolina, South Carolina, Georgia, and Florida (*Figure 1; Appendix A*). While the "coastal zone" is defined differently by each of these states (coastal counties in North and South Carolina; — 60 miles inland and

extent of tidal influence in Georgia; the entire state of Florida), the "coastal ocean" is herein considered to include offshore waters to the extent of the U.S. EEZ, and inshore waters to the extent of tidal influence. Systems chosen for this study were based on a list developed by the SouthEast Coastal Ocean Observing Regional Association (SECOORA). Since no official definition or standard criteria exist for COOS; those systems that included elements most consistent with the list on page 4 of this report were included in this study.

Figure 1 *Coastal Ocean Observing Systems in the Southeast region*

Caro-COOPS	Carolinas Coastal Ocean Observing and Prediction System
COMPS	Coastal Ocean Monitoring and Prediction System
CORMP	Coastal Ocean Research and Monitoring Program
EFSIS	East Florida Shelf Information System
	Explorer of the Seas Program
NC-COOS	North Carolina Coastal Ocean Observing System
PORTS	Physical Oceanographic Real-Time System Tampa Bay Program
SABSOON	South Atlantic Bight Synoptic Offshore Observational Network
SEACOOS	Southeast Atlantic Coastal Ocean Observing System



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Study Approach

This study builds on the results of a recent Coastal States Organization (CSO) survey, and subsequent workshop, that identified information and technology needs of coastal managers in the Southeast region (CSO, 2004a; 2004b). Through extensive document reviews and personal interviews with observing system representatives (*Appendix D*), the activities and applications of COOS in the Southeast were recorded and compared with the needs of the coastal managers identified in these CSO reports. This was accomplished through a two-phased study approach. The first phase involved the development of a matrix to compare the priority research, information, and technology needs expressed by coastal managers with existing and planned observations, models, and information products available from Southeast regional COOS. A comprehensive review of each observing system's website and other publications was conducted to document available data and information products. Interviews were then arranged with each observing system's principle investigators and/or extension specialists to confirm ongoing and planned activities. Finally, a completed, draft matrix was circulated to all interviewees for reviews and comments. This effort was conducted during the time period of October 2005 to June 2006.

The second phase involved further interviews and research to identify and highlight case studies of interactions between COOS and Southeastern coastal managers. The two case studies presented in Section 2 provide detailed accounts of collaborations between coastal managers and COOS scientists and personnel in the Southeast region. The first describes a significant, local-scale hypoxia event that is benefiting from COOS-CZM collaborations in Long Bay, South Carolina; the second, a regional COOS effort to support coastal managers in responding to Hurricanes Katrina and Rita.

Section 1
Information Needs of Southeastern Coastal Managers

Overview of Coastal States Organization Findings

In an effort to raise awareness of the research, information, and technology needs of coastal resource managers, the Coastal States Organization administered a needs assessment survey during 2003/2004 to coastal managers nationwide (CSO, 2004a). Responses came from 230 coastal managers representing 33 of the 35 coastal states and territories, including water quality, wetlands, fisheries, and floodplain managers. According to survey results for the Southeast region, the top three management issues were land use change, habitat degradation, and nutrient enrichment. Within these categories, top-ranked technology needs included improved models for prediction and simulation, high-resolution remote sensing, and cost-effective long-term monitoring and sampling capabilities.

Later that year, the CSO organized a workshop with support from the NOAA National Ocean Service and the Southeast Coastal Ocean Observing Regional Association to identify coastal managers' needs for evolving coastal ocean observing systems in the Southeast (CSO, 2004b). Participants included twenty-five state and federal managers from the region with expertise in water quality, marine resources, land use, environmental protection, shoreline hazards, and emergency response interests. The workshop resulted in a number of recommended actions to improve regional interaction between the management and observing communities. In addition, key data and information products needed from the observing community were identified under the management categories of "shoreline change and hazards" and "water quality." The information and technology needs identified through these two studies were compiled and are presented in the following subsections.

"Observation" Needs

Within the two CSO reports described above, twenty-one general "observation" needs were identified (*Table 1*) as important to addressing coastal management issues in the Southeast. We defined "observations" to include raw or extrapolated data directly or indirectly collected or monitored, including test-bed or trial data collections.

Observations related to "sediment dynamics" were defined to include direct measures of sediment quality, supply, or transport. "Surface/subsurface currents" measurements were defined to include measurements made by either HF Radar (maps of near-surface current fields) and/or Acoustic Doppler Current Profilers (ADCPs; water column profiles of current velocity and direction at individual sites). "Phytoplankton" observations were defined to include measurements of chlorophyll a fluorescence for estimation of phytoplankton abundance. "Aerial/Satellite imagery" was defined to include remotely derived observations of changing shorelines or spatial patterns of oceanographic or meteorological parameters. Observations of "shoreline erosion" were defined to include direct measures of erosion, or erosional forcings (directional wave fields).

Table 1 *"Observation" Needs Identified through CSO Surveys and Workshops.*
List adapted from CSO, 2004a; 2004b.

Shoreline Water Level	Surface/subsurface currents	Surface Waves
Surface Winds	Surface Salinity	Surface Temperature
Light Penetration	Bathymetry/bottom type	Organic Matter/BOD*
Nutrients	pH	Dissolved Oxygen
Pathogens/toxins	Phytoplankton	Zooplankton
Bacteria	Aerial/satellite imagery	Riverine/Rainfall Inputs
Sediment Dynamics	Turbidity	Shoreline Erosion

* *Biochemical Oxygen Demand*

Modeling and "Information Product" Needs

Thirteen categories of desired modeling applications and/or information products were also identified (*Table 2*). Categories were based on management issues ranked as "very important" or "important" by Southeastern coastal managers in the CSO reports. Examples of desired applications within each category are described immediately below Table 2.

Table 2 *Categories of Priority Information Needs Identified in Surveys of Coastal Managers in the Southeast.*
List adapted from CSO, 2004a; 2004b.

Land Use Impacts	Habitat Change
Coastal Hazards	Nutrient Enrichment
Ocean Management	Ecosystem Management
Sediment Dynamics	Rainfall
Non-indigenous Species	Circulation
Dredging Effects	Environmental Contamination
Marine Debris	

Examples of Desired Applications

For each of the categories listed in Table 2, several examples of desired applications were provided by managers during the CSO needs assessments:

Coastal Hazards: Areas subject to erosion; risk and vulnerability assessments; simulation models; advanced detection and warning.

Ecosystem Management: Habitat and biodiversity loss; cumulative impact assessments; mapping and data acquisition; physical and chemical properties; simulation and prediction models.

Environmental Contamination: Mercury, sewage, and pathogens; identification and remediation; real-time detection.

Habitat Change: Impact assessments, trend analyses (especially in salt marsh areas).

Land Use Impacts: Effects of coastal development; and development of indicators to link land use with ecosystem impacts.

Marine Debris: Source identification; removal and disposal.

Non-indigenous Species: Effects, control and prevention; early detection; treatment and removal technologies.

Nutrient Enrichment: Stormwater sources; urban and agricultural runoff; pollutant source tracking/identification.

Ocean Management: Issues related to developments or alterations of the marine environment, including: drilling and pipeline effects; shipping; resource mining, marine protected areas.

Sediment Dynamics: Disposal options; transport patterns; dredging impacts; beach renourishment.

In relation to the observations, models, and information products described above, the emerging capabilities of southeastern coastal ocean observing system are examined in Section 2.

Section 2
Expanding Southeastern Coastal Ocean Observing Systems

Increasing Observations

Based on the present range of observing activities, all COOS examined in this study are collecting some observations consistent with coastal management needs. In situ towers, buoys, drifters, and other platforms outfitted with oceanographic and meteorological instrumentation and near real-time telemetry capabilities are the primary methods of data collection. Vessel transects are in use by the CORMP program in North and South Carolina and the Explorer of the Seas Program. In situ platforms are located in both nearshore and offshore waters of the U.S. EEZ. SEACOOS collaborators recently developed a comprehensive map of in situ observing platforms in the Southeast, including regional COOS and national backbone systems (*Figure 2*).

Figure 2 *Preliminary Map of Observing System Locations and Providers in the Southeast*

▶ *http://seacoos.org/documents/providers.jpg (2005)*

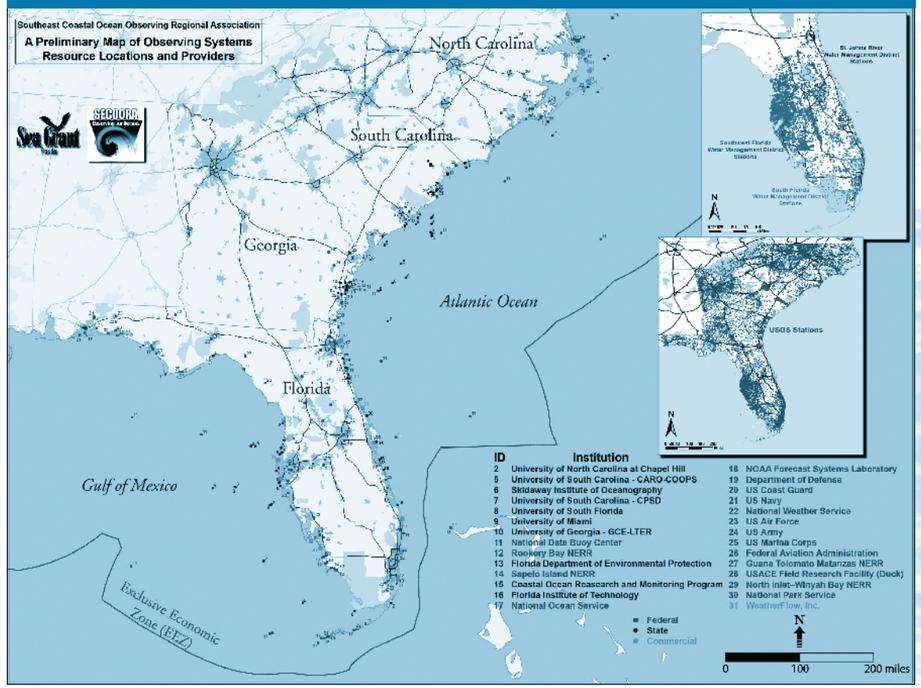


Table 3 *Observations being collected by Southeastern COOS in relation to needs of coastal management community.*

Observations	Caro-COOPS	COMPS	CORMP	EFSIS	Explorer of the Seas	NCCOOS	PORTS	SABSOON	SEACOOS
Shoreline Water Level	R	R		R			R		R
Surface/subsurface currents	R	R	R	R	R	R	R	R	R
Surface Waves	●	R	R	R		R	R	R	R
Surface Winds	R	R	R	R	R	R	R	R	R
Surface Salinity	R	R	R	R	R	R		R	R
Surface Water Temp.	R	R	R	R	R	R	R	R	R
Light Penetration			●					R	T
Bathymetry/bottom type		●	●						●
Organic Matter/BOD					R				
Nutrients			●						
pH							●		T
Dissolved Oxygen	R		R		R	R	●		T
Pathogens/toxins									
Phytoplankton	R	R	●		R			R	T
Zooplankton			●						
Bacteria									
Remote/aerial imagery		R	●						R
Riverine/Rainfall Input		R	R			R	●		
Sediment Dynamics		●							●
Turbidity		R	R						T
Shoreline Erosion		●						T	T

R *Data available in near real-time.*

T *Parameter currently measured in trial/test bed location.*

A summary of observations available from Southeastern COOS in relation to coastal managers' needs is found in Table 3. Surface and/or subsurface currents, surface water temperature, and surface wind observations are being collected by all nine systems studied. Other frequently collected observations are surface waves and surface salinity. Dissolved oxygen and chlorophyll fluorescence observations (as a proxy for phytoplankton abundance) are collected by approximately 2/3 of the systems, and nearly 1/2 report shoreline water level, riverine discharge, and/or rainfall observations. 1/3 of the systems report observations of light penetration (attenuation), turbidity, shoreline erosion, bathymetry/bottom types, and/or satellite-derived observations of oceanographic or meteorological parameters, such as surface winds and sea surface temperatures. Observations related to pH and sediment dynamics are each collected by two of the nine systems. Observations related to nutrients, zooplankton, and organic matter/BOD were each reported by only one of the nine systems. None of the systems currently monitor for pathogens/toxins or bacteria levels. Technologies supporting the continuous and near-real time monitoring of biological parameters remain less available than those supporting physical oceanographic and meteorological parameters (Alliance for Coastal Technologies, 2000; see also Appendix C, BIOSENSE/SO COOL program).

New Modeling and Forecasting Applications

Modeling applications were identified as models or forecasts developed by the COOS or developed using data and/or observations collected by the COOS. Using this definition, modeling and nowcast/forecast applications are being developed by seven of the nine COOS studied *(Table 4*). The majority of systems have developed circulation models; many of these have been tailored to coastal hazards and ecosystem management issues. Some models have also been applied toward environmental contamination, sediment dynamics, and nutrient enrichment issues. No models were yet available or specifically designed to aid in needs pertaining to land use change, habitat change, rainfall inputs, or non-indigenous species. However, many of the models are designed to meet multiple user needs, and could be adapted for applications related to other management issues. For example, circulation models can provide a foundation for dredging; marine debris, and ocean management applications even if they are not specifically designed with those categories in mind.

Table 4 *Modeling and Forecasting Applications of Southeastern COOS in relation to needs of coastal management community.*

Data Need	Caro-COOPS	COMPS	CORMP	EFSIS	NCCOOS	PORTS	SEACOOS
Land Use Impacts							
Habitat Change							2
Coastal Hazards	1 2	1 2	1 2	1		1 2	1 2
Nutrient Enrichment		1	1 2	1			
Ocean Management				1			
Ecosystem Management	2	1 2	2	1		1	1 2
Sediment Dynamics		1 2		1			1 2
Rainfall							
Circulation*	1	1		1	1	1	1
Non-indigenous Species							
Environmental Contamination			1 2	1		1 2	1 2
Dredging Effects				1			
Marine Debris				1			
Other	2			2	2		2

1 *Model/forecasting application available for described need.*

2 *Tailored Management Product available for described need.*

* *Circulation models provide a foundation for other applications, such as dredging, marine debris and ocean management applications, even if they are not specifically being used for those purposes at this time.*

Caro-COOPS Models

The Caro-COOPS modeling system consists of a connected, fully three-dimensional, time dependent, continental margin and estuary-coupled hydrodynamic model. Investigators at North Carolina State University have developed an adaptive grid "Coastal and Estuarine Modeling and Environmental Prediction System" (CEMEPS), which constitutes the backbone model for the system and contains a suite of interactively linked atmospheric, oceanic, estuary, and river model components. The oceanic modeling component is a coupled wave-current-tide simulation system, consisting principally of the Princeton University Ocean Model (POM) that is interactively coupled to a third generation wave model called WAM Cycle4 and an inundation modeling program. A shallow water wave model using an improved coupling formulation is being incorporated into the wave-current coupled modeling system for the entire coastal region of South Atlantic Bight. The output from the oceanic module includes a distribution map of storm surge elevation and inundation, surface and subsurface current fields, significant wave height and frequency fields, and tidal elevation and currents. CEMEPS is being used to develop pre-generated storm surge scenarios along the coastal Carolinas.

COMPS Models

COMPS has developed several models that meet coastal management needs relating to nutrient enrichment, ecosystem management, sediment dynamics and circulation. The Ocean Circulation Group within the COMPS program is presently running three different types of models for the purposes of: 1) linking the coastal ocean with the deep-ocean, 2) linking the coastal ocean with the estuaries, and 3) examining the estuaries themselves. For 1) a regional WFS ROMS model is nested within the 1/12th degree North Atlantic HYCOM. For 2) the FVCOM (Finite Volume Coastal Ocean Model) is used with present emphasis on Tampa Bay and Charlotte Harbor estuary interactions. For 3) the FVCOM is also used, with applications specific to Tampa Bay and Charlotte Harbor, and with a new applications in development for Rookery Bay and Naples Bay. The FVCOM is also used for hurricane storm surge simulations, and was recently used in an analysis of Hurricane Charlie impacts.

CORMP Models

Models developed through CORMP meet three of the described needs including coastal hazards, nutrient enrichment and environmental contamination. The Cape Fear River Estuary and Coastal Estuarine Marine Prediction System (CEMAPS) is a system of hydrodynamic and ecological models for North Carolina coastal waters that are designed to

reconstruct past oceanographic conditions and forecast future conditions (using the CEMEPS model described under Caro-COOPS as its foundation). Water quality components examine how phytoplankton productivity is influenced by nutrient loadings, light attenuation, and varying river discharges, for example.

EFSIS Models

EFSIS models, also based on the Princeton Ocean Model, include time series of 3-dimensional currents, temperature, sea surface height with turbulence variables, and particle trajectories for the East Florida Shelf.

NC-COOS Models

NC-COOS runs a high spatial resolution model of the currents driven by the winds and tides, the ADCIRC circulation model, intended to support inundation modeling and particle movement in the nearshore and estuarine waters (e.g. hazardous material transport). NC-COOS also runs a coarser resolution model of the 3D circulation and mass fields (the Quoddy regional circulation model nested with the basin-scale HYbrid Coordinate Ocean Model (HYCOM) model to provide particle trajectory estimates in coastal waters, and to study fisheries oceanography, for example.

PORTS Models

In addition to providing critical data in support of shipping operations, PORTS has modeling applications serving coastal hazard, ecosystem management, circulation and environmental contamination needs. PORTS data were used by the University of South Florida to develop a 3-dimensional time-dependent model of circulation hydrodynamics in Tampa Bay. A similar 3-dimensional estuarine coastal ocean model was designed for water level, temperature, salinity and wind-stress in Tampa Bay. The model also predicts flow rates for rivers on the lateral boundaries of Tampa Bay.

SEACOOS Models

SEACOOS currently offers three major modeling applications (based on modeling work at the University of South Florida, University of Miami, and the University of North Carolina at Chapel Hill) that meet five of the needs specified by the CSO surveys, including coastal hazards, ecosystem management, sediment dynamics, circulation, and environmental contamination. An interactive model display is readily available via the Internet and provides currents, winds and surface elevation in near real-time and hindcast. SEACOOS has also developed an ocean circulation model, which is forced by winds at sea surface and tidal elevations. The model layers include elevation, depth-averaged currents and particle trajectories. SEACOOS's Mississippi River Plume Flow Model models particle trajectories originating from the Mississippi River delta and was recently used in response to Hurricane Katrina (*see Case Study #2*).

Developing Information Products

Information products were defined as any decision-support tools or other applications developed by the observing system and tailored or translated specifically to aid coastal managers in decision-making or policy development. Applying this definition, southeastern COOS have already developed tailored information products or decision-support tools related to some of the identified coastal management needs in Table 4. Most systems have at least one product related to either coastal hazards or ecosystem management issues. A few systems have developed products relating to sediment dynamics and environmental contamination. Products addressing habitat change and nutrient enrichment needs have been developed by one system. No products have yet been developed which are focused on land use impacts, ocean management, rainfall, circulation, non-indigenous species, dredging effects, or marine debris. However, four systems have tailored products that meet "other" coastal management needs, such as metadata management (Caro-COOPS/SEACOOS). Descriptions of tailored management products developed by Southeastern COOS are provided in the following subsections.

Caro-COOPS Products

Several Caro-COOPS products have been designed to provide useful information to the coastal management community. The "StormMap" product provides pre-generated and real-time storm surge projections for North and South Carolina, and presently includes an interactive database of over 1,000 pre-generated storm surge scenarios for major cities along the South Carolina coast. Caro-COOPS has also collaborated with CORMP and the National Weather Service to develop the "Carolina's Coast" website, which provides a one-stop shop for real-time information relating to rainfall, tides, and hazardous conditions warnings and other parameters for the coastal Carolinas (*see Appendix C*). Another project, the Long Bay Ecosystem Management website, was developed to provide marine and coastal observations related to the Long Bay, SC area specifically for coastal managers (*see Case Study #1, Section 3*). Caro-COOPS has also developed a product called "Meta-Door," an online metadata entry tool. This product will support marine-related data integration and documentation, and improved access for the coastal management community.

COMPS Products

COMPS offers several products developed through the Ocean Circulation Group at the University of South Florida, providing information related to Tampa Bay and the West Florida shelf. For example, COMPS provides nowcast and 84-hour forecast products for winds, sea level, and currents in the West Florida Shelf. COMPS also aided in the development of a water mass tracking tool, which provides particle trajectories originating from the Mississippi River Delta and entering the Gulf of Mexico Loop Current (*described further in Case Study #2*).

CORMP Products

CORMP has a number of user-friendly, web-based tools that can easily be used for coastal management applications. River Run is an interactive data display tool available on the CORMP website, allowing users to interact with water quality data from the lower Cape Fear River. Similarly, Ocean View and OB3M are interactive user-input web based tools used for visualization and exploration of data from moorings off the North Carolina Coast (OB3M) and global oceans (Ocean View). CORMP has developed a rip current tool providing graphical representation of the probabilities of rip currents along beaches from Pender County, North Carolina to Georgetown County, South Carolina. Warnings and probabilities are issued twice daily. The autonomous underwater vehicle (AUV glider) program has been recently used by CORMP to take oceanographic measurements to depths of 200m for up to one month. Glider data are then processed and made available on-line for easy access and use. CORMP is also a partner in the development of "Carolinas Coast" (*above*).

EFSIS Products

EFSIS has developed several data synthesis products for the management community, including maps, transects, and vertical and horizontal water column profiles of the East Florida Shelf.

PORTS Products

PORTS has created an oil spill simulation product for Tampa Bay. The simulation uses a passive diffusion scheme to project progression of mock oil-spills to Tampa Bay's oil-spill response team in hourly increments. The simulation provides oceanographic and meteorological data to aid in the rapid response clean-up plan for hazardous spills in Tampa Bay. It projects the rate of spread and maximum potential spill distribution. Through use of this model PORTS plays a role as an Initial Responder in Tampa Bay's Contingency Plan for Oil and Hazardous Substance Pollution Response, which is a U.S. Coast Guard initiative.

SEACOOS Products

SEACOOS has created a web-based, interactive portal that provides near real-time and archived observations and models covering the entire SEACOOS domain. Map layers can be viewed individually or compiled to display multiple oceanic parameters. Recently, SEACOOS investigators published a synthesis document describing major coastal ocean events in the Southeast Region (SEACOOS, 2005). SEACOOS's Mississippi River Plume Flow Model models particle trajectories originating from the Mississippi River delta and was recently used to aid in Hurricane Katrina fallout (*see case study #2*).

Section 3
Case Studies

Local Scale: Long Bay Ecosystem Management Project

Located in the South Atlantic Bight off the coasts of North and South Carolina, Long Bay extends from the Cape Fear River, NC to Winyah Bay, SC, and includes the popular tourist destination of the Myrtle Beach "Grand Strand in South Carolina (*Figure 3*). In July 2004 a hypoxia event occurred in the waters off Myrtle Beach. Coastal hypoxia events are episodes of low dissolved oxygen concentrations (< 2mg/L) that can significantly impact biological communities in the coastal ocean. State managers were initially alerted to the event due to unusually high flounder catches in the area. Initial measurements revealed low dissolved oxygen levels in nearshore, bottom waters and a high degree of water column stratification.

Figure 3 *Study Area — Long Bay*

In response to this event, the South Carolina Department of Health and Environmental Control -Office of Ocean and Coastal Resource Management (SCDHEC-OCRM) held a workshop in September 2004 with concerned scientists and local management agencies to discuss what was known about the event, and to develop a response plan for future hypoxia events. Follow-up workshops were held in June and July of 2005.

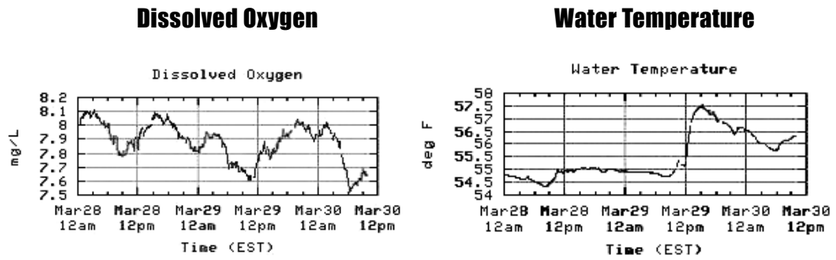
Following on the hypoxia event and subsequent workshops, the Long Bay Ecosystem Management Project was funded through SECOORA and the Southeastern Universities Research Association (SURA) in June 2005. The project was developed through a partnership of the science and management communities, including ocean observing systems, state management agencies, and university researchers.

The four goals of the project include: 1) Identification of data needed to assess the role of anthropogenic influences and natural oceanographic processes in the development of the hypoxia event; 2) Integration of existing data and coordination of research efforts; 3) Development of a "rapid response" sampling strategy for any future anomalous water quality events in the area; and 4) Development of a web-based application to provide information about local environmental monitoring, research efforts, and data resources to the coastal management community.

Regional and sub-regional components of the U.S. Integrated Ocean Observing System, including the Southeast Atlantic Coastal Ocean Observing System (SEACOOS) and the Carolinas Coastal Ocean Observing and Prediction System (Caro-COOPS), have provided additional research support for the project. These systems have assisted in the identification, aggregation, and analysis of relevant local oceanographic data; provided near real-time, continuous data from existing coastal monitoring stations; and established new observing infrastructure designed to meet local management and research needs. Recently, through a joint effort between SEACOOS, Caro-COOPS, and SCDHEC-OCRM, a dissolved oxygen sensor was installed at Springmaid Pier – an existing SEACOOS observation platform located within the study area. The sensor is intended to provide early alerts of low DO conditions and long-term continuous physical water quality observations.

With support from Caro-COOPS, SEACOOS, and SECOORA, a web-portal, the Long Bay Ecosystem Management Website (http://nautilus.baruch.sc.edu/longbay), is currently under construction. The site is being developed specifically for coastal resource scientists and managers and is designed to: 1) Integrate current, historic, and modeled sources of marine and coastal observations in Long Bay; 2) Provide an inventory of relevant information through local and user-friendly metadata records; and 3) Facilitate the coordination of regional research efforts. Real-time observations of dissolved oxygen, water temperature and salinity from the Springmaid Pier sensor are available on the site (*Figure 4*). The portal also provides information relating to the hypoxia study initiated after the 2004 event, including presentations and meeting notes from the summer 2005 workshops; the "Rapid Response Sampling Plan"; and a flyer used to inform the public about hypoxia events in Long Bay and enlist their aid in reporting unusual conditions.

Figure 4 *Examples of near real-time measurements available through the Long Bay Ecosystem Management website.*



Partners and Affiliates of the Long Bay Ecosystem Management Project

The Long Bay Ecosystem Management project developed from a science to management partnership between regional coastal ocean observing systems, academic institutions, and state agencies including: Caro-COOPS and SEACOOS; the South Carolina Department of Health and Environmental Control (SCDHEC); South Carolina Department of Natural Resources (SCDNR); Southeast Coastal Ocean Observing Regional Association (SECOORA); University of South Carolina Baruch Institute for Marine and Coastal Sciences; Coastal Carolina University Center for Marine and Wetland Studies; North Inlet-Winyah Bay National Estuarine Research Reserve; and the South Carolina Sea Grant Consortium.

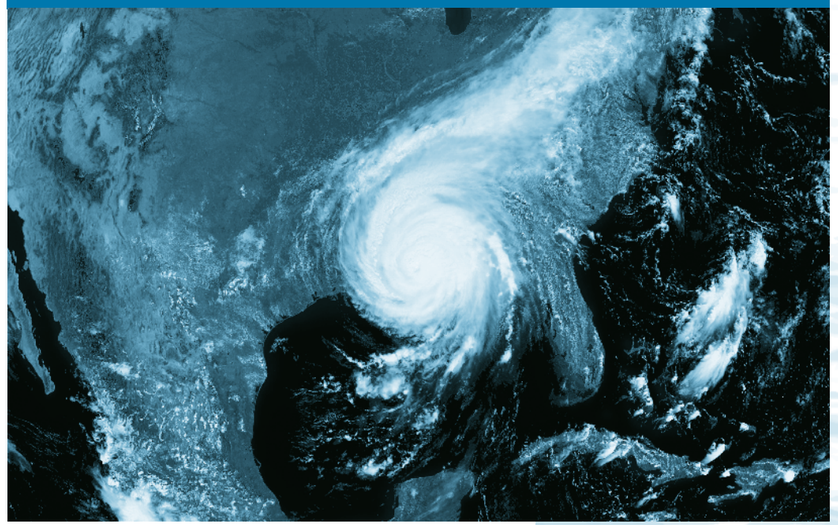
Regional Scale: Post-Katrina Water Flow and Particle Tracking

Hurricane Katrina made landfall on August 29, 2005 in Southeast Louisiana as a Category 3 storm (*Figure 5*). This was one of the costliest and deadliest hurricanes in American history, causing massive damage along the Louisiana, Mississippi and Alabama coastlines. Large-scale destruction resulted in floodwaters filled with organic and chemical pollutants, including sewage and oil covering large tracts of the impacted area. Debris and particles entering into the Gulf of Mexico Loop Current via the Mississippi River Delta were also of concern. This resulted in an immediate need to determine and forecast circulation patterns, pollutant concentrations, and particle trajectories for the affected area. Scientists affiliated with regional coastal ocean observing systems (SEACOOS and COMPS) immediately began work on designing products to aid public health officials, hazardous materials experts, and disaster response workers in tracking and forecasting the fallout from Hurricane Katrina.

Flow Prediction of Toxic Waters

SEACOOS – affiliated scientists at the University of North Carolina worked with researchers at NOAA's Coast Survey Development Laboratory to develop forecast products to predict the circulation of Katrina-polluted waters. They used a 3-dimensional computer program capable of modeling water levels and flow known as the Advanced Circulation Model (ADCIRC). ADCIRC had previously been used for after-the-fact analyses of coastal storm surges. Information gained from ADCIRC modeling was used in conjunction with a NOAA weather forecasting model to provide daily coastal circulation and pollution concentration forecasts for areas affected by Katrina to aid in cleanup and recovery efforts. Due to the success of this tool in responding to Hurricane Katrina, the same system was extended to areas affected by Hurricane Rita.

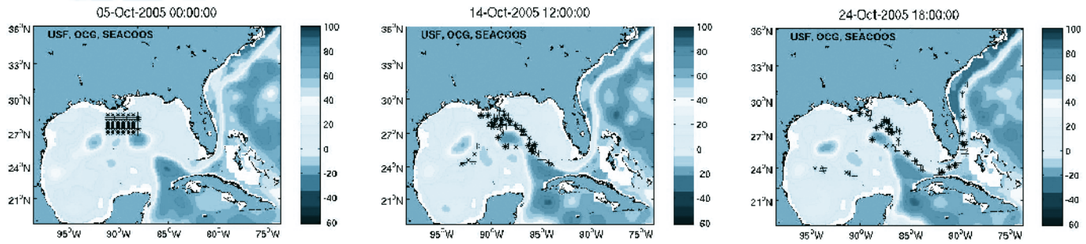
Figure 5 ▶ *Hurricane Katrina makes landfall August 29, 2005.*
http://www.nnvl.noaa.gov/cgi-bin/index.cgi?page=items&ser=109672



Particle Tracking

Through a joint SEACOOS and COMPS effort, the University of South Florida Ocean Circulation group has been designing a forecast product to generate trajectories for particles originating between the Mississippi River Delta and the Gulf of Mexico Loop Current. Using geostrophic currents and satellite-derived sea surface height measurements, particles trajectories originating from the Mississippi River can be tracked. Model simulations are based on particles starting in, and to the south of, the Mississippi River Delta. Observations and analyses were in progress when Hurricane Katrina hit, allowing for particle trajectories resulting from the storm to be forecasted and tracked. Through this model, researchers have been able to determine the extent to which debris and other environmental contaminants originating from the Mississippi River Delta were able to enter the Loop Current and be transported to the Florida Keys and up the eastern coast of Florida (SEACOOS, 2006; Simoniello, personal communication).

Figure 6 *Particles: a) originating from the Mississippi River Delta*
b) entering the Loop Current and
c) traveling beyond the Florida Keys
http://ocgmod2.marine.usf.edu/Drifters/lastOct05/drifters.html



Partners and Affiliates involved in Post-Katrina Flow and Particle Tracking
SEACOOS and COMPS; the University of North Carolina's (UNC) Marine Sciences Program and Renaissance Computing Institute (RENCI); University of South Florida College of Marine Science Ocean Circulation Group (USF-CMSOCG); National Oceanic and Atmospheric Administration's (NOAA)/National Ocean Service (NOS)/Coast Survey Development Laboratory (CSDL); National Center for Supercomputing Applications (NCSA).

Conclusions and Future Directions

Southeastern coastal managers have recently described a wide range of science and technology needs. It is unlikely that any one system will meet all of these needs for any given issue or geographic area. Yet many observing systems in the Southeast are already providing information related to many of the observational, modeling, and product needs described by coastal managers. While many of the COOS in the Southeast are still in development, it should be noted how quickly they have established near real-time data collection systems, integrated models, and management-related information products. Although it is beyond the scope of this report to evaluate or validate these data and information products, they hold promise for vastly improving the temporal and spatial resolution of coastal and ocean data, and advancing data integration and synthesis across multiple data collection and modeling efforts. In addition, the expanding availability of continuous, near real-time data via the Internet is proving critical in alerting managers to anomalous conditions and increasing understanding of long-term system dynamics. Finally, an expanding variety of information products is also being developed by Southeastern COOS to aid in coastal management. These products provide a critical link between the scientific and management communities by making data and models more easily accessible and "user-friendly." Each of these contributions should prove especially important in meeting longstanding information needs described by coastal managers nationwide.

Newly forming "regional associations" (RAs) are intended to ensure that IOOS subprograms evolve into fully operational, user-driven regional observing systems (NFRA, 2006). As a first step, it will be necessary for RAs to inventory and characterize the efforts being undertaken by each regional observing system, the societal goals they are meant to achieve, and the audiences or "user groups" whose needs will be addressed. In the southeast region, it is hoped that this research will support the newly formed Southeast Coastal Ocean Observing Regional Association (SECOORA) in guiding the development of regional and subregional systems to meet the needs of the coastal management community. There is a continuing need for outreach activities and joint planning efforts to ensure that the developing observing systems and related information products will meet the information needs of coastal managers in the southeast region.

Future Directions

Based on recommendations from the U.S. Ocean Commission (ACWI, 2006), an effort is currently underway to create a National Water Quality Monitoring Network. As of April 2006, the National Water Quality Monitoring Council had released an initial National Monitoring Network Design. The network is designed to be linked with the national IOOS and its eleven regions. The design approach is multi-resource and multidisciplinary to integrate water resource components from the uplands to the coast, integrating physical, chemical and biological water resource characteristics. To keep up with ever-changing technologies, the network is also being designed to incorporate flexibility in monitoring locations and technologies. Resource classifications include wetlands, beaches, estuaries, groundwater, offshore, nearshore, rivers, lakes and atmospheric deposition (ACWI, 2006). The network will be carried out mainly through collaboration between Federal Agencies.

The U.S. Commission on Ocean Policy recognized that the National Water Quality Monitoring Network should be integrated with the IOOS in its development, as stated in its report: "Because these systems will overlap in coastal areas, they should be closely coordinated to ensure compatibility of information. At some point, the National Water Quality Monitoring Network and the IOOS should both become components of a true Earth observing system that links land, air, and water around the globe." The linkage of these two systems should result in synergies that support the information needs of the coastal management community, and would benefit from continuing input from coastal managers in the Southeast region.

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Appendix A

Southeastern Coastal Zone Management Programs

North Carolina

Lead Agency: Division of Coastal Management (DCM), under Department of Environment, Health and Natural Resources.

Key Legislative Acts: Coastal Area Management Act (CAMA)

Federal Approval: 1978

Program Description & Goals: CAMA applies to twenty counties located within North Carolina's coastal region. It is designed to aid in land use planning and is designed to balance environmental protection with economic development. CAMA permits are required for developments in areas of environmental concern, including almost any development in the 20 CAMA counties. The DCM also staff's North Carolina's Coastal Resources Commission and is responsible for programs including: permitting and enforcement; land-use planning; public beach and waterfront access; North Carolina Coastal Reserves; grants for marine sewage pump-out; erosion rates; wetlands conservation and restoration, and assessing coastal development impacts. Data is collected and analyzed for erosion rates, wetlands conservation and restoration, and to assess coastal development impacts.

Special Management Areas: North Carolina National Estuarine Research Reserve and the Monitor National Marine Sanctuary.

Further information: **http://dcm2.ehnr.state.nc.us/**.

South Carolina

Lead Agency: Office of Ocean and Coastal Resource Management within the Department of Health and Environmental Control (SCDHEC-OCRM).

Key Legislative Acts: Tidelands and Wetlands Act of 1977; 1988 Beachfront Management Act.

Federal Approval: 1979

Program Description & Goals: OCRM is responsible for implementing the Coastal Zone Management Plan, which includes: management of wetland alterations; stormwater and land disturbance activities; certification of all federal and state permits, and direction of federal actions and any alterations of critical areas (tidal and intertidal waters, beaches and dunes). Other objectives and goals include the preservation of sensitive natural, historic, and cultural resources through regulations and guidance and providing technical expertise when needed to aid in coastal management issues. OCRM encourages low impact and alternative development techniques aimed at preserving water quality and environmental integrity.

Special Management Areas: ACE Basin and North Inlet-Winyah Bay National Estuarine Research Reserves; Special Area Management Plans (e.g. Charleston Harbor, Beaufort, Ashley River).

Further information: **http://www.scdhec.net/environment/ocrm/**.

Georgia

Lead Agency: Coastal Resources Division of the Department of Natural Resources

Key Legislative Acts: Georgia Coastal Management Act; Coastal Marshlands Protection Act; the Shore Protection Act

Federal Approval: 1998

Program Description & Goals: Georgia's Coastal Management Program is intended to balance economic development in the coastal zone with preservation of natural, environmental, historic, archaeological and recreational resources. Under the administration from the Department of Natural Resources, Coastal Resource Division, a network of agencies with management authority was established to fulfill requirements of the Georgia Coastal Management Act. The Coastal Management Program is responsible for water quality monitoring; consistency review of federal permits, licenses and projects in the coastal area; outreach and education; marsh and shore permitting, and Georgia's coastal non-point source program.

Special Management Areas: Gray's Reef National Marine Sanctuary and Sapelo Island National Estuarine Research Reserve.

Further information: **http://crd.dnr.state.ga.us/**.

Florida

Lead Agency: Florida Department of Environmental Protection

Key Legislative Acts: The Florida Coastal Management Program (FCMP) is composed of 23 different statutes including, but not limited to: Coastal Construction; State Lands; Land Conservation Action of 1972; Living Resources; Tourism and Economic Development; Pollutant Spill Prevention; Water Resources, and Sources of Water and Air.

Federal Approval: 1981

Program Description & Goals: The program coordinates activities of eight state agencies, five water management districts, and local governments to meet the responsibilities outlined in the FCMP. The two main goals for the FCMP are to protect the ecological integrity of coastal resources and build and maintain economic and cultural values of coastal communities. To achieve these goals, the FCMP works to integrate policies to meet both natural and political needs. The Florida State Clearinghouse and the Federal Consistency units under the FCMP help improve intergovernmental coordination and communication by circulation and review of federal and state activities that impact coastal resources. The Local Program Assistance unit aids resource managers and other users through educational materials and training programs.

Special Management Areas: Florida Keys National Marine Sanctuary; Apalachicola Bay; Rookery Bay and Guana Tolomato Matanzas National Estuarine Research Reserves; Everglades National Park

Further information: **http://www.dep.state.fl.us/cmp/**.

Appendix B

Southeastern Coastal Ocean Observing Systems

Carolinas Coastal Ocean Observing and Prediction System (Caro-COOPS) – Caro-COOPS is based on an instrumented array of coastal and offshore moorings deployed off of the coast of the Carolinas. Caro-COOPS has operational buoys located off the North and South Carolina coasts, providing real-time oceanographic and meteorological data. Information from this observing system will be used to monitor and model estuarine and coastal ocean conditions, as well as develop predictive tools and forecasts for coastal managers. Caro-COOPS is a partnership led by the University of South Carolina, with North Carolina State University and the University of North Carolina at Wilmington. For a complete listing of investigators and cooperators, and for more information about Caro-COOPS, visit **http://www.caro-coops.org**.

Coastal Ocean Research and Monitoring Program (CORMP) – CORMP is a research program off the coast of the Carolinas run by the University of North Carolina at Wilmington. The program is designed to provide an inter-disciplinary science based framework to support sound public policy leading to wise coastal use, sustainable fisheries and improved coastal ocean ecosystem health. CORMP maintains moored stations, buoys and pier stations in Onslow Bay and Long Bay and monitors the mouth of the Cape Fear River. For a complete listing of investigators and cooperators and for more information about CORMP, please visit **http://www.cormp.org**.

East Florida Shelf Information System (EFSIS) – EFSIS is run through the University of Miami Rosenstiel School of Marine and Atmospheric Science as a regional partner in SEACOOS. It provides observational data, forecast products and a detailed oceanographic model for the East Florida shelf. For a complete listing of investigators and cooperators and additional information about EFSIS, please visit **http://efsis.rsmas.miami.edu/**.

Explorer of the Seas – The Explorer of the Seas is a cruise ship outfitted with ocean and atmospheric science labs. Royal Caribbean, AOML, and the University of Miami's Rosentiel School of Marine and Atmospheric Science run the ship's research laboratory. Explorer of the Seas runs weekly cruises between Miami and the Eastern Caribbean, crossing the Gulf Stream and major passages between the Atlantic Ocean and Caribbean Sea. The repetitive track of the ship allows for scientists to obtain long-time series of continuous ocean and atmospheric measurements in the region. Additional program and personnel information is available at: **http://www.rsmas.miami.edu/rccl/index.html**.

North Carolina Coastal Ocean Observing System (NC-COOS) – The University of North Carolina at Chapel Hill is implementing a real-time Coastal Ocean Observing System (NC-COOS) for North Carolina that will provide additional data needed to give more accurate predictions of ocean and coastal processes. NC-COOS consists of an array of instrumentation both along the coast and offshore, combined with numerical circulation models, and builds upon existing in-situ measurements and modeling programs funded by various state and federal agencies. This observing system fulfills all of the requirements of the Coastal Module of the Global Ocean Observing System (CMGOOS). Data and model products are disseminated in real-time to federal, state, and local emergency management officials via the internet. For a complete listing of investigators and cooperators and more information about NC-COOS, please visit **http://nccoos.unc.edu/**.

Physical Oceanographic Real-Time System (PORTS) Tampa Bay Program – PORTS is a program of the National Ocean Service that supports safe and cost-efficient navigation by providing shipmasters and pilots with accurate real-time information required to avoid groundings and collisions. It includes centralized data acquisition and dissemination systems that provide real-time oceanographic and meteorological data. PORTS also provides nowcasts and predictions with circulation models. For a complete listing of investigators and cooperators and information about Tampa Bay PORTS, visit **http://tidesandcurrents.noaa.gov/ports.html.**

South Atlantic Bight Synoptic Offshore Observational Network (SABSOON) – SABSOON provides synoptic observations of large-scale oceanographic processes on the continental shelf in real-time. The goal of this is to develop an interannual to decadal database on ocean atmosphere interactions. The SABSOON network is capable of providing important information on cross-shelf exchange, storm effects and atmospheric transport. For a listing of investigators and more information about SABSOON, visit **http://www.skio.peachnet.edu/projects/sabsoon.html**.

Southeast Atlantic Coastal Ocean Observing System (SEACOOS) – SEACOOS works to develop a regional coastal ocean observing system for the Southeastern United States. SEACOOS is composed of subsystems of observing, modeling, data management, and extension and education activities, and seeks to increase the quantity and quality of environmental information from the coastal ocean and facilitate its use in a wide range of societal, scientific, and educational applications. The founding institutions are regional research universities (University of North Carolina-Chapel Hill, University of South Carolina, University of Miami, University of South Florida and Skidaway Oceanographic Institution), and expanding membership includes state and federal agencies and private sector interests. For a complete listing of SEACOOS investigators and cooperators and for more information about SEACOOS, please visit, **http://www.seacoos.org**.

West Florida Coastal Ocean Monitoring and Prediction System (COMPS) – COMPS is designed to support a variety of operational and research efforts, including storm surge prediction, environmental protection, coastal erosion and sediment transport, red tide research and satellite remote sensing of coastal ocean dynamics. Implemented by the University of South Florida, COMPS has instrumentation both along the coast and offshore. It provides data needed for a variety of management issues for West Florida including storm surge predictions, safe marine navigation and fisheries management. For a complete listing of investigators and cooperators and for more information about COMPS please visit **http://comps.marine.usf.edu/**.

Appendix C
Additional Data Sources for Coastal Managers

Southeast Coastal Ocean Observing Regional Association (SECOORA) – SECOORA is one of 11 Regional Associations (RAs) being established through IOOS. The RAs will be guided by the priorities of user groups within each region. The RAs will help steer programs of the U.S. federal agencies, ensuring that the national information "backbone" maintained under IOOS meets the needs of the regional Observing System nodes and their users. For more information, please visit: **http://www.secoora.org/**.

National Backbone of IOOS

National Data Buoy Center (NDBC) – NDBC is a part of the National Weather Service (NWS); it provides frequent, high-quality marine meteorological observations from offshore buoys and onshore coasal stations. NDBC's mission is to provide comprehensive, reliable systems and marine observations in support of NOAA and the NWS and promote public safety. The NDBC network is composed of approximately 90 buoys and 60 Coastal Marine Automated Network (C-MAN) stations in U.S. coastal waters, estuaries and the Great Lakes. In addition to its buoys NDBC manages the Volunteer Observing Ship program, which collects meteorological and oceanographic observations. NDBC also links to regional observing systems, such as the SEACOOS, Caro-COOPS, and CORMP networks to provide even more observations through their network. Additional information about NDBC can be found at: **http://www.ndbc.noaa.gov/**.

National Estuarine Research Reserve System (NERRS) – The NERR program is a network of 27 protected estuaries, rivers and bays throughout the United States. NERR sites are protected for long-term research, water-quality monitoring, education and coastal stewardship. The program was established by the 1972 Coastal Zone Management Act, as amended, and is a partnership between NOAA and coastal states. Reserves are managed on a daily basis by state agencies or local universities. The NERR system-wide monitoring program tracks short and long term changes in estuarine waters, and provide monitoring data to coastal managers for decision-making issues. Since all NERR sites monitor some of the same water quality parameters, a centralized data management office provides quality assurance and control for the entire system. The office also creates standard operating procedures for the entire NERRS so that data are collected in the same way at all NERRS sites. NERR sites relevant to this study include: the North Carolina NERR; North Inlet-Winyah Bay, South Carolina; ACE Basin, South Carolina; Sapelo Island, Georgia; Guana Tolomato Matanzas, Florida; Rookery Bay, Florida and; Apalachicola, Florida. Additional information about the NERR program is available at: **http://nerrs.noaa.gov/**.

National Water Level Observation Network (NWLON) – NWLON is the operational component of the National Water Level Observation Program out of NOAA's Center for Operational Oceanographic Products and Services. It provides tidal datums to determine U.S. coastal marine boundaries and support for NOAA tsunami and storm surge warning programs. There are approximately 175 NWLON stations along the U.S. coasts and waters. One hundred forty (140) of these stations have been operational for over 19 years and continuously transmit near-real-time data. There are approximately 29 NWLON stations located in North Carolina, South Carolina, Georgia and Florida. Additional information is available at: **http://tidesandcurrents.noaa.gov/nwlon.html**.

National Weather Service Digital Forecast Products – A new Interactive Forecast Preparation System (IFPS) is being implemented in the NWS which provides not only for preparation of familiar text and voiced products, but also creates in digital (i .e., numeric al) form the data from which these products are prepared. These digital forecasts are put into the National Digital Forecast Database (NDFD). In essence, the forecaster now enters the forecast variables in digital form instead of redundantly typing several products containing largely the same information. But the real power of a digital database is that it opens the door for providing much more forecast information and in more useful forms. The NDFD will contain much more data than the NWS was previously able to provide, at time scales as small as hourly and space scales of a few miles. For more information, see: **http://www.nws.noaa.gov/om/brochures/GeneralNDFDHandout.pdf**.

Physical Oceanographic Real-Time System (PORTS) – PORTS a National Ocean Service program designed to support safe and cost-efficient navigation. The program provides real-time information to ship masters and pilots to help avoid groundings and collisions. Relevant data measurements include real-time water levels, currents and oceanographic and meteorological parameters. PORTS is also designed to provide environmental protection from marine accidents that could cause hazardous material spills, destroying local ecosystems. There are thirteen (13) PORTS systems currently operating throughout the United States. Additional information regarding PORTS is available at: **http://tidesandcurrents.noaa.gov/ports.html**.

U.S. Geological Survey (USGS) Stream Gauge Network – USGS collects water resource data from all major rivers, lakes, reservoirs, wells and springs throughout the United States. There are approximately 1.5 million sites in the U.S. including Washington D.C. and Puerto Rico. Data collected includes temperature, conductance, pH, nutrients, pesticides and volatile organic compounds. Data are relayed through satellite and processed in real-time and made available online for public use. Additional data and information can be found at: **http://waterdata.usgs.gov/nwis**.

Additional Southeastern Data Resources

Aquarius – Aquarius is an undersea laboratory operated through a partnership among NOAA, the National Undersea Research Program, the University of North Carolina at Wilmington and the National Undersea Research Center. The laboratory supports scientific efforts designed to better understand oceans and coastal resources by allowing scientists to live and work on the seafloor for extended amounts of time. Aquarius was first deployed southeast of Key Largo, Florida in the Florida Keys National Marine Sanctuary in 1992 and is still currently in the sanctuary near deep coral reefs at a depth of 63 feet. Wireless telemetry links computers in the laboratory back to a shore base. Aquarius supports a wide array of scientific projects ranging nutrient cycling in coral reefs to fish behavior. The laboratory is also used for Navy dive training and NASA Space Simulations. Additional information on Aquarius is available at: **http://www.uncw.edu/aquarius/index.html**.

BIOSENSE / SO COOL (Sarasota Operations Coastal Ocean Observing Laboratory) – BIOSENSE is a real and near real-time biological observing system currently in development through a partnership between the University of South Florida (USF) College of Marine Science and Mote Marine Laboratory (MML). The system will be deployed off the central gulf coast of Florida. The goals of the BIOSENSE program are to provide new biological data that can be integrated with physical and chemical observing platforms; provide new technology that can be applied to a wide range of habitats and; integrate with physical observing platforms and form collaborations to strength MML and partner organizations. Physical and chemical oceanographic platforms and models from USF will be combined with biological sensing systems from MML. The system will also expand MML's existing SO-COOL clearinghouse. Specific monitoring parameters for BIOSENSE include: phytoplankton abundance and community structure; red tide toxins; local faunal stock assessments and acoustically tagged sharks and sea turtles. The program also plans to incorporate water chemistry, zooplankton abundance, habitat characterization, benthic parameters, and public beach health within the near future. Additional information about the BIOSENSE/SO-COOL program is available at: **http://www.nova.edu/ocean/flcoos/kirkpatrick_meeting3.pdf**.

Carolinas Coast – This website is being established through a partnership between Caro-COOPS, CORMP, SEACOOS, and NOAA's Weather Forecast Offices in Wilmington, NC and Charleston, SC (NWS-ILM and NWS-CHS). NWS-ILM is responsible for the coastal region extending from Surf City in North Carolina to South Santee River in South Carolina, and extending to 40 nautical miles offshore. NWS-CHS is responsible for the coastal region extending from South Santee River into Georgia, and extending out to 40 nautical miles offshore of South Carolina. The Carolinas Coast website, upon completion, is meant to serve as the new template for the NWS-ILM and NWS-CHS "Marine" webpages, and provides one-stop shopping for near real-time observations, forecasts, warnings, and tides for a variety of users. Additional information is available at: **http://nautilus.baruch.sc.edu/carolinas/carolinascoast.php**.

FerryMon – The FerryMon program provides daily water quality monitoring data for North Carolina's Albermarle-Pamlico Estuary System through the existing local ferry system. FerryMon is designed to provide a long-term and cost-effective monitoring system and to evaluate the status and trends in water quality in the estuary system. Three ferries are equipped with water quality monitoring sensors to collect samples every three minutes while the ferry is en route. The program is a joint effort between North Carolina's Department of Environmental and Natural Resources, Duke University Marine Laboratory, University of North Carolina at Chapel Hill and the North Carolina Department of Transportation. Additional information is available at: **http://www.ferrymon.org**.

Florida Coastal Ocean Observing System (FL COOS) Caucus – Started in June 2005, the FL COOS Caucus is composed of scientists, coastal managers, regulatory personnel and private sector provider and user groups. These individuals meet to discuss and determine useful policy parameters and options consistent with Florida's ocean resource and ecosystem needs. One of the key goals of the FL COOS Caucus is to develop action plans to accomplish specific tasks related to Florida's ocean interests. Further information is available at: **http://www.nova.edu/ocean/flcoos/**.

State of the Southeast Coastal Ocean Report – Developed by SEACOOS, the report aims to provide a periodic summary of current COOS activities in the Southeast. The report looks at the status of the regional coastal ocean observing system, recent major environmentally significant events and updates from multiple regional and sub-regional COOS. The first complete report can be found on-line via the SEACOOS website at: **http://seacoos.org/documents/se-coastal-ocean-report.pdf**.

South Florida Ocean Measurement Center (SFOMC) – Currently in development the SFOMC is a partnership of government and academia. The Office of Naval Research is guiding construction of an in-water laboratory near Ft. Lauderdale. The center plans to provide real time environmental data from the atmosphere, air/ocean interface and sub bottom. Further information is available at: **http://www.sfomc.org**.

Southeastern Universities Research Assoc. Coastal Ocean Observing & Prediction Program – The Southeastern Universities Research Association (SURA) Coastal Ocean Observing and Prediction (SCOOP) program is a multi institution collaboration sponsored by the Office of Naval Research

and NOAA's Coastal Services Center. SCOOP brings together a diverse group of researchers with expertise in both oceanography and information technology (IT). SCOOP partners are helping to implement the goals of the IOOS and the plans developed by Ocean.US by developing a service-oriented architecture to support community collaboration on shared scientific goals. The vision of the program is to provide community-wide information services and technologies that advance the sciences of prediction and hazard planning for our nation's coastal populations. The SCOOP Program is also working toward integrating the independently-operating, diverse, coastal and land-based observing systems into a "system of systems" - a key priority for the Global Earth Observation System of Systems (GEOSS) and the Integrated Earth Observing System (IEOS). Further information is available at: **http://scoop.sura.org/**.

Sustained Ecological Research Related to Management of the Florida Keys Seascape (SEAKEYS) – SEAKEYS is run as a collaborative program between NOAA and the Florida Institute of Oceanography. SEAKEYS is a long-term monitoring and research effort along Florida's coral reef tract. It was originally developed to monitor the decline in coral reefs and provide data and options for research management in the Florida Keys. NOAA C-MAN stations in the SEAKEYS area have been updated to not only provide the standard meteorological data, but oceanographic observations relating to salinity, sea temperature and turbidity as well. SEAKEYS / C-MAN data are handled through two software programs: The Environmental Information Synthesizer for Expert Systems (EISES) and the Coral Reef Early Warning System (CREWS). EISES and CREWS are used to alert local managers when oceanic conditions are conducive to coral bleaching and other conditions such as harmful algal blooms. Further information about SEAKEYS can be found at: **http://www.coral.noaa.gov/seakeys/index.shtml**.

Appendix D
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Photos courtesy of the Southeast Atlantic Coastal Ocean Observing System.